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High-Frequency Acoustics Propagation Effects of Bubbles in Shallow Water

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LONG-TERM GOAL

The long-term goal of this work is to contribute to the understanding of the effects of surf and wind-wave induced bubble fields and their inhomogeneities on the propagation and scattering of sound at high frequencies in shallow water. The ultimate goal of this work is to develop the means of incorporating these effects into acoustic models.

OBJECTIVES

The objectives of this current effort are to identify and describe major alterations in the acoustic fields and signal waveforms caused by the strong and coupled attenuative and dispersive effects of bubbles and to understand their combined effects on acoustic fields to the extent that their waveforms can be predicted in important bubbly environments.

APPROACH

Our approach has been to address several aspects of the effects of bubbles on acoustic propagation in shallow-water environments. We have continued to analyze data taken in earlier experiments, develop tools for studying the relationships between bubble populations and propagation effects, contribute to the planning for a new experiment in FY02, and work toward understanding the impacts of bubbles on practical applications of acoustics in the ocean environment.

A new approach we pursued this year is centered on the effects of bubbles on hydrographic surveys. In this regard we have analyzed the potential errors that may be made in depth and location determination when only temperature, salinity, and depth is used to determine sounds speed and angle of transmission in multibeam hydrographic systems when there are bubbles present.

WORK COMPLETED

In coordination with the other researchers, we have provided forward-propagation data from the previous experiments that have allowed interpretations based on tomographic reconstruction of bubble clouds and new understands of waveforms based on Kramers/Kronig relationships and simulation studies that combine and enhance the attenuative and dispersive effects. We now have in place simulation software that can accomplish aspects of this task. Results of this work were published by Dan Rouseff, et al., 2001. Frank Henyey has provided an algorithm for describing the waveform as it propagates in an attenuative and dispersive medium. Henyey has applied the algorithm to a case that simulates the signals and resulting attenuation we used but with a few simplifying assumptions. We have been trying to apply the algorithm to the actual data in order to describe and understand the actual waveforms recorded. Ultimately we hope to extract sound-speed versus frequency information for the experimental data that results from the matching of the waveforms.

In the previous year, we had published a paper on a new iterative technique for solving a set of accurate attenuation measurements for the bubble distribution. As the result of a continued effort this year, we carried the technique out to an arbitrary number of iterations. This has resulted in a recursion relationship that we feel should have wide applications to the inversion of various resonance phenomena. The results of that work has been submitted to the Journal of the Acoustical Society (Elmore and Caruthers, submitted).

As a result of several discussions with scientists at the Naval Oceanographic Office, a problem with the use of multibeam hydrographic systems in bubbly environments was identified. The hydrographic community had long known of the problem of bubbles sweep down under the hull affecting the results of surveys. The analysis we conducted indicated that bubbles naturally occurring in the sea or those due to the passage of the survey ship through the wake of another ship could, under some real circumstances, cause errors that exceed the International Hydrographic Organization (IHO) standards (cf, Sebastian and Caruthers, submitted). Figure 1 shows a possible case where bubbles could cause significant errors.